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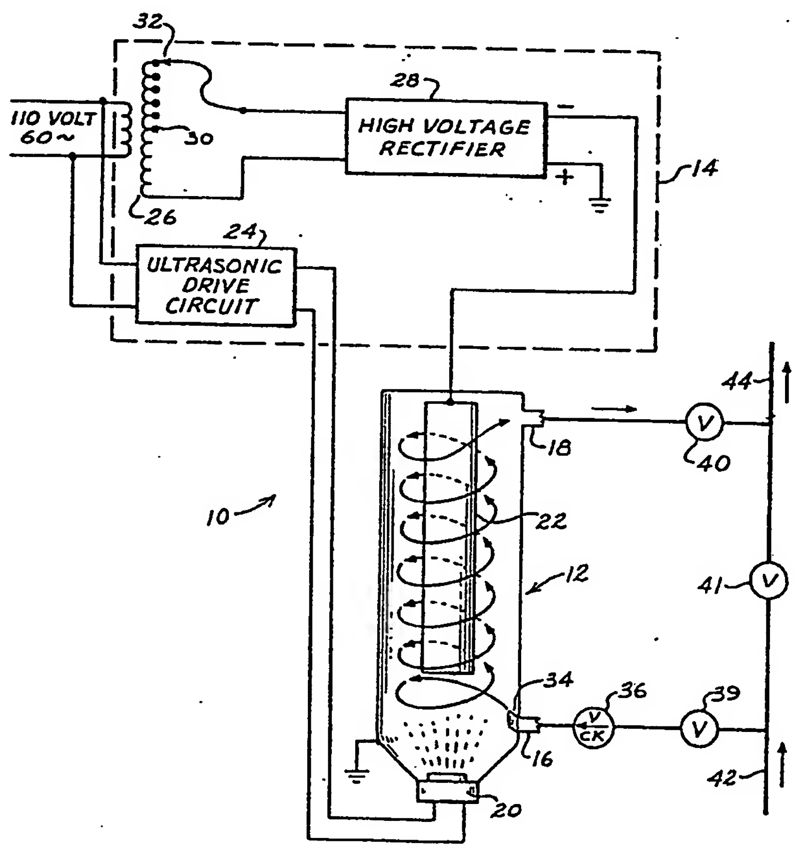
(54) Title: WATER TREATMENT APPARATUS AND METHOD FOR TREATING WATER

(57) Abstract

Method and apparatus (Fig. 1) for treating water to increase the solubility of certain salts, and to enhance the ability of the water to dissolve accumulated scale from equipment such as pipers and boilers. The water is treated by subjecting it to the combined action of an electrostatic field (22) and ultrasonic energy (20) in the same chamber. After treatment the water is flowed through the equipment to be cleaned and dissolves accumulated scale and salts. The treated water can also be used for other purposes.



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Description

Water Treatment Apparatus and Method for Treating Water

Technical Field

This invention relates to treating water and other liquids or slurries under the combined action of an electric field and sonic or ultrasonic energy to enhance the characteristics of the water.

More particularly, the invention relates to treating water under the combined and synergistic action of ultrasonic energy and an electrical field while the water is in motion, to temporarily impart to the water a vastly increased ability of the water to dissolve various salts and to simultaneously kill and destroy various organisms which may be in the water.

Background of the Invention

Minerals present in potable natural and city water are known to present many problems such as causing scale formation in pipes, boilers, and other process equipmetn. Water heaters and low pressure boilers are particularly susceptible to scaling as are plumbing and piping of surface condensers, engine cooling systems, cooling towers, air conditioners, etc. In such systems where much of the water is recirculated, the problem becomes much more acute, and large quantities of chemicals are presently required to maintain the system operable. Even with these chemicals, substantial drain-off is required, with a corresponding requirement for makeup water.

Even where substantial quantities of chemicals are added to the water, problems of scaling or organism growth require frequent maintenance and cleaning of the systems to maintain operation at reasonable efficiency.

In water heating or cooling systems, scale formation substantially reduces heat transfer thereby substantially reducing the capacity of a system to either heat or cool, and vastly increasing the energy required to operate the systems because of such poor heat transfer.

Where process steam or water is generated for use in processing food or treating food containers, the problem becomes far more acute because only certain chemicals are regarded to be safe by the Food and Drug Administration for use in water for food processing, or for cleaning the equipment.

Correspondingly, such chemical treatment is usually unsatisfactory, and cleaning such systems is both time consuming and requires shutdown of the system.

Summary

In accordance with this invention, there is provided a method and apparatus for treating water which not only eliminates the need for chemical additives in the water, but also ultimately eliminates existing scale from the system, over a period of time, while the system is in use. No shutdown is required.

This is accomplished in accordance with this ivnention by subjecting the water to the combined actions of ultrasonic energy and an electric field while the water flows through a treating chamber. One remarkable result of such treatment is an increase, on the order of a factor of 10, of the quantity of salts such as calcium carbonate, which can dissolve in the water. While such increase of the solubility of the water is only temporary, the effects of the treatment last a sufficient time to enable the water to descale various systems while the systems continue in operation. An advantage of the temporary effects of the treatment is that the water can be safely discharged into sewage systems of septic tanks without adversely affecting the sewage systems.

These advantageous effects are attained by flowing the water through an electrostatic field while simultaneously imparting ultrasonic energy to the water, and then flowing the so treated water to the apparatus in which it is used. The water can be feed water for a process steam boiler, or can be recirculated water from a cooling tower or other system where a portion of the water is reused. It should be noticed particularly that the water is treated, not in the apparatus in which it is used, but in a separate apparatus which can easily be connected to the piping of any desired system and water either used or to be used in the system simply flows through the treatment apparatus.

What this combined treatment actually does to the water is not precisely known. It is believed that some ionization of the water occurs, water molecules are made unstable, and peroxide-like oxidants are formed. However, it has been found that the treated water has the ability ot dissolve scale, and to inhibit the ability of a mineral to form crystalline structures. Amorphous structures were found in some of the dissolved scale. In addition, a substantial decrease in biological activity in the water after treatment has been observed.

Correspondingly, an object of this invention is a method of treating water by subjecting it to the combined action of an electrostatic field and sonic energy to impart unique characteristics to the water, nd then flowing the water to a desired system for use.

Another object is a method of treating water wherein water flowing through a chamber is simultaneously subjected to an electrostatic field and ultrasonic energy.

Another object is a method of treating water by flowing water around an insulated high voltage electrode while simultaneously imparting sonic energy into the water.

Another object is a method of treating water by causing the water to swirl around an insulated high voltage electrode while simultaneously imparting sonic energy into the water.

A further object is a method of treating water by flowing the water through a chamber around a high voltage insulated electrode along a generally helical upward path while applying sonic energy to the water.

A further object is apparatus for treating water including an insulated electrode charged with high voltage and disposed in a chamber, and means in the chamber for imparting ultrasonic energy to water flowing through the chamber and around the electrode.

A further object is to provide a water treatment apparatus comprising a cylindrical chamber, an insulated electrode extending axially of the chamber, and an ultrasonic transducer for imparting sonic energy to the water flowing through the annulus between the chamber and the electrode.

A further object is to provide apparatus for treating water in which an elongate electrode extends axially of an elongate chamber, an ultrasonic transducer is positioned at the end of the chamber opposite the electrode, water flows through the chamber from an inlet adjacent the transducer, and the transducer directs sonic energy toward the electrode.

A further object is water treatment apparatus including an elongate insulated electrode positioned in an upper portion of an elongated chamber, an ultrasonic transducer at a lower portion of the chamber for directing ultrasonic waves toward the electrode, a water inlet at the lower portion of the chamber, a water outlet at the upper portion of the chamber, means for applying a high voltage to the electrode, and means for energizing the transducer.

A further object is such an apparatus which is operable at relatively high temperatures and pressures.

A still further object is a unique water treatment apparatus of unique construction including a uniquely insulated electrode with long life and durability.

Numerous other objects, features, and advantages of the invention will become apparent with reference to the accompanying drawings.

Brief Description of Drawings

Fig. 1 is a drawing schematically showing the system of the invention and its power supply;

Fig. 2 is a view in axial section of a liquid treatment unit according to the invention;

Fig. 3 is a view in section taken along line 3-3 of Fig. 2;

Fig. 4 is a schematic showing the unit of Fig. 3 connected to treat boiler feed water; and

Fig. 5 is a schematic showing the unit of Fig. 3 connected to treat recirculated water from a bottle warmer.

Detailed Description of a Preferred Embodiment

Fig. 1 shows the system of this invention. As shown, there is a water treatment system 10 including a treatment chamber 12 and a power supply 14. Chamber 12 is vertically elongated and has a lower inlet 16 and an upper outlet 18. At the bottom of the chamber is an ultrasonic transducer 20. Positioned within the chamber is an insulated electrode 22 which is wholly insulated from both the metal forming the wall of chamber 12 as well as with respect to the water flowing through the chamber from inlet 16 to outlet 18.

Power supply 14 includes an ultrasonic drive circuit 24 which drives transducer 20 at its resonant frequency which can be a desired ultrasonic frequency between 25 K Hz and 50 K Hz. A preferred output

frequency for driver 24 is 38 K Hz and transducer 20 is then selected to have the same resonant frequency of 38 K Hz. Where ultrasonic driver 24 has an output of a different frequency, it is of course necessary to select a transducer 20 with a corresponding resonant frequency, since thepower output of readily available transducers drops sharply at frequencies more than about 5% on either side of their resonant frequency. Transducer 20 is preferably of the magnetostrictive type but can be any relatively high power ultrasonic transducer. It is preferred that ultrasonic drive circuit 24 and transducer 20 be of the type which maintains a relatively constant input of ultrasonic energy into the water in chamber 12 despite variations of water pressure in the chamber.

Power supply 14 also includes a high voltage low current power supply for electrode 22, this power supply including a high voltage multi-tap transformer 26, the output of which is connected to a high voltage rectifier 28. The positive output of the rectifier is grounded and the negative output is connected to the inside of electrode 22. Electrode 22 cooperates with the metal wall of chamber 12 to form a capacitor, the negatively charged plate of which is the electrode, and the positively charged plate of which is the metal wall of chamber 12. Since electrode 22 is wholly insulated with respect to chamber 12 and the water flowing through the chamber, there is in effect, no current flow from electrode 22 to the wall of chamber 12. The field prodcued between electrode 22 and the wall of chamber 12 is believed to be electrostatic.

Transformer 26 is provided with a plurality of taps 30 to permit obtaining different voltages from the transformer, and hence, from the rectifier, by changing the connection between a connector 32 and a desired tap on the secondary of the transformer winding. Preferably, the taps permit the selection of

different voltages from 4 KV to 12 KV at 1 KV intervals. Such an arrangement permits changing the magnitude of the field between electrode 22 and the wall of chamber 12. A typical output of the rectifier is 7 KV at 0.5 milliamps current.

Adjacent water inlet 16 of chamber 12 is a deflector 34 which causes the water entering the chamber through inlet 16 to flow in a generally helical path upwardly through the chamber and around electrode 22. A check valve 36 adjacent water inlet 16 is provided to maintain the chamber full of water at all times when the unit is in operation.

Valves 39, 40, and 41 can be provided to permit by-passing the treatment unit should it be desired to disconnect the unit from the piping system. By closing valves 39 and 40 and opening valve 41, inlet water from line 42 passes directly to an outlet flow line 44.

Fig. 2 shows the chamber 12 in greater detail. As shown at Figs. 2, chamber 12 has a cylindrical sidewall 50 preferably of stainless steel, and which is elongated. At the top of the sidewall is a connecting flange 52 to which is secured a cover 54. Matching bolt holes in flange 52 and cover 54 permit removably securing the cover to the top of the sidewall with bolts 56.

Mounted on the center of cover 54, and extending into the unit is the electrode 22. Electrode 22 takes the form of a metal pipe 60 secured to a cylindrical insulator block 63 at its upper end and via which the electrode is mechanically connected to and supported by cover 54, in insulated relation to the cover. There is an insulator block 64 at the lower end of pipe 60. Each insulator block is a tight force fit in its end of pipe 60. Pipe 60 is covered with an electircally insulating TEFLON sleeve 70, the lower end of which is deformed

inwardly over the end of insulator 64, and which is sealed by plate 72 and a gasket and seal assembly 74 to prevent any water from entering the electrode. Bolted to plate 72 are metal centering bars 73 extending at right angles to each other of a length only slightly less than the I.D. of wall 50, and which maintain the lower end of the electrode generally centered in chamber 12.

Similarly, the upper end of TEFLON sleeve 70 is deformed inwardly across insulator 62 and is sealed to the insulator with a gasket and seal assembly 75 between the cover and the upper end of the electrode. Insulator 62 is secured to cover 54 by bolts which pass through openings in the cover and are threaded into blind threaded openings in the insulator 62. Insulator 62 has an upwardly projecting smaller diameter end portion 76 which extends through seal 75 and opening 78 in cover 54. The seal assembly 75 between insulator 62 and the cover prevents any leakage of water from chamber 12 of the unit at this connection. Extending through a small diameter opening 80 in insulator 62 is a wire 82 which is electrically connected to the inside surface of pipe 60. The upper end of the wire is connected to an electrical connector 84 at the outer end of portion 76 of insulator 62 to provide for connecting the electrode to the negative terminal of the high voltage power supply. At the lower end of chamber 12 is a bell-shaped bottom casing 90. Casing 90 is welded to the bottom of the sidewall and has an inside diameter at its lower end 92 which is only very slightly greater than the diameter of transducer 20. Transducer 20 is secured to and sealed to a bottom plate 94 which is secured to the bottom of bell-shaped casing 90 with bolts 96 which extend through bottom plate 94 and into threaded openings in the bottom of bell casing 90.

Inlet 16 takes the form of a pipe nipple 98 threaded into a sleeve 97 which can be threaded into or welded to the sidewall 50 at a location just above bell 90. Extending across the inner end of pipe nipple 98 which forms the inlet is a baffle plate 102 secured to a thin nut 100 (Fig. 3) which is threaded onto an externally threaded portion of sleeve 97 which extends a short distance inwardly of side wall 50. This baffle plate imparts to the water entering the chamber 12, a component of velocity generally tangential with respect to sidewall 50. Flow of the water upwardly through the chamber is generally helical so that the water swirls around electrode 22 before leaving the chamber through outlet 18 which takes the form of a pipe nipple 104 threaded into the sidewall 50.

The unit shown at Fig. 2 is capable of treating water at flow rates of up to 500 gallons per minute, depending on the condition of the water. The unit is approximately 4' high, sidewall 50 has an inside diameter of approximately 5", and electrode 22 has a diameter of approximately 2-1/2", and extends along the axis of sidewall 50 for substantially the distance between inlet 16 and outlet 18. The inside diameter 92 at the bottom of the bell is approximately 3" and transducer 20 has essentially the same diameter.

Fig. 4 shows an installation of the treatment unit of this invention for treating feed water for a relatively low pressure steam boiler. Unit 12 was connected in the manner generally shown at Fig. 1, between a boiler 112 and its feed water pump 109. Valves 36 and 39-41 were provided. Feed water from pump 109 passed through pipe 110 and unit 12 (valve 41 closed and valves 39-40 open) and then to boiler 112. A voltage of 7000 volts was applied to electrode 22 of the unit 12 and the ultrasonic transducer was driven at 38 K Hz. The flow of water through the unit 12 to the boiler was on

the order of 50 gallons per minute. Substantial scale was noticed in the blow-off water from the boiler at the blow-off outlet 114, for a period of several weeks. The capacity of the boiler gradually increased and the process steam available from the boiler increased by approximately 60% over a period of two months. Subsequent examination of the boiler indicated no substantial scale in the boiler. Unit 12 continues to treat the feed water to the boiler and prevents formation of new scale.

Unit 12 was connected as shown at Fig. 5 to a water heater 120. The heated water from heater 120 was circulated through a commercial bottle warmer 122, through unit 12, and then back to the heater 120 by a pump 124. Prior to installing unit 12, the heater 120 operating at maximum capacity, was capable of maintaining the water in bottle warmer 122 at a temperature of 120°F. During the first several days after unit 12 was installed and the water treated as previously described, the water flowing from heater 120 was observed to be black and scaly. For the first several weeks of operation bottle warmer 122 was drained at the end of each day's use, by opening drain valve 126, to remove accumulated scale. Two weeks later, it was noticed that the color of the effluent drain water had changed from black to yellow, and a week later, the effluent was clear. Algae and slime which normally formed in the bottle warmer were completely gone, and the temperature of the water in the warmer had increased from 120° to 140°F. While changes of the water in the system are still required at periodic intervals, no shut-down or maintenance of the system has been required since unit 12 was installed. The total coliform count after four weeks of operation from the time of initial installation of unit 12 was zero.

The installation shown at Fig. 4 is typical of installations where water fed to a device such as a boiler is not recirculated. Similar installations can be used for cleaning plumbing systems, for example, in older hotels, with excellent results. It has been found that the system operates most efficiently where the unit 12 is installed as close as possible to, for example, boiler 112. Distances which require piping on the order of 10' to the boiler are quite satisfactory, but it is preferred that the distance from the treatment unit to the system which uses the water should not exceed about 75'.

It has been found that the unit 12 will clean scale clogged pipes simply by installing the unit at the water inlet to the building. In this way, pipes of a hotel were cleaned with the resultant dissolved scale simply flowing through the plumbing within several months after installation.

Where the unit 12, as shown at Fig. 5, is used to treat recirculated water, it is again preferred that the unit be installed at a location relatively close to the system which uses the treated water.

During operation of the unit when the water is recirculated, it is preferred that the water be kept at a pH of between 6.5 and 8.7. This pH range can usually be maintained by draining water from the system and adding make up water. However, chemicals can be added to the water to maintain this pH range.

While a preferred embodiment of this invention has been shown and described, and several methods of treating water in accordance with this invention have been described, it is to be understood that changes can be made without departing from the scope of this invention.

Claims

1. Water treatment apparatus comprising:

a chamber having an inlet and an outlet;

means for directing ultrasonic energy into water flowing through said chamber between the inlet and the outlet;

an electrode in said chamber extending along at least a portion of the path of travel of water flowing between said inlet and said outlet;

means electrically insulating said electrode with respect to water flowing through said chamber; and

means for applying a relatively high voltage to said electrode.

2. Water treatment apparatus according to Claim 1 wherein said electrode comprises a metal pipe and an insulating sleeve of TEFLON extending around and in sealed relation to said pipe.

3. Water treatment apparatus according to Claim 1 wherein said means for applying a high voltage to said electrode comprises power supply means for applying a voltage to said electrode greater than 3,000 volts.

4. Water treatment apparatus according to Claim 1 wherein said means for directing ultrasonic energy into water in said chamber comprises means for directing ultrasonic energy at a frequency in the range of between 25 K Hz and 50 K Hz.

5. Water treatment apparatus according to Claim 4 wherein said means for directing ultrasonic energy into the water comprises means for directing ultrasonic energy into the water at a frequency of 38 K Hz.

6. Water treatment apparatus according to Claim 1 wherein said electrode comprises a cylindrical electrode, said chamber comprises a cylindrical chamber and said apparatus further comprises means for causing water flowing through said chamber to flow generally helically around said electrode.

7. Apparatus according to Claim 6 further comprising means suspending said electrode from an upper part of said chamber, and means at a lower end of said electrode for maintaining the electrode centered in said chamber.

8. A method of treating a liquid comprising flowing the liquid along an insulated high voltage electrode while simultaneously directing sonic energy into the liquid.

9. A method of removing water deposited scale from equipment comprising flowing water along an insulated high voltage electrode while simultaneously directing ultrasonic energy into the water, and then flowing the water through the equipment.

10. A mehtod of temporarily increasing the ability of an aqueous containing liquid to dissolve salts comprising, flowing the water adjacent a high voltage electrode insulated from the liquid while directing ultrasonic energy into the liquid.

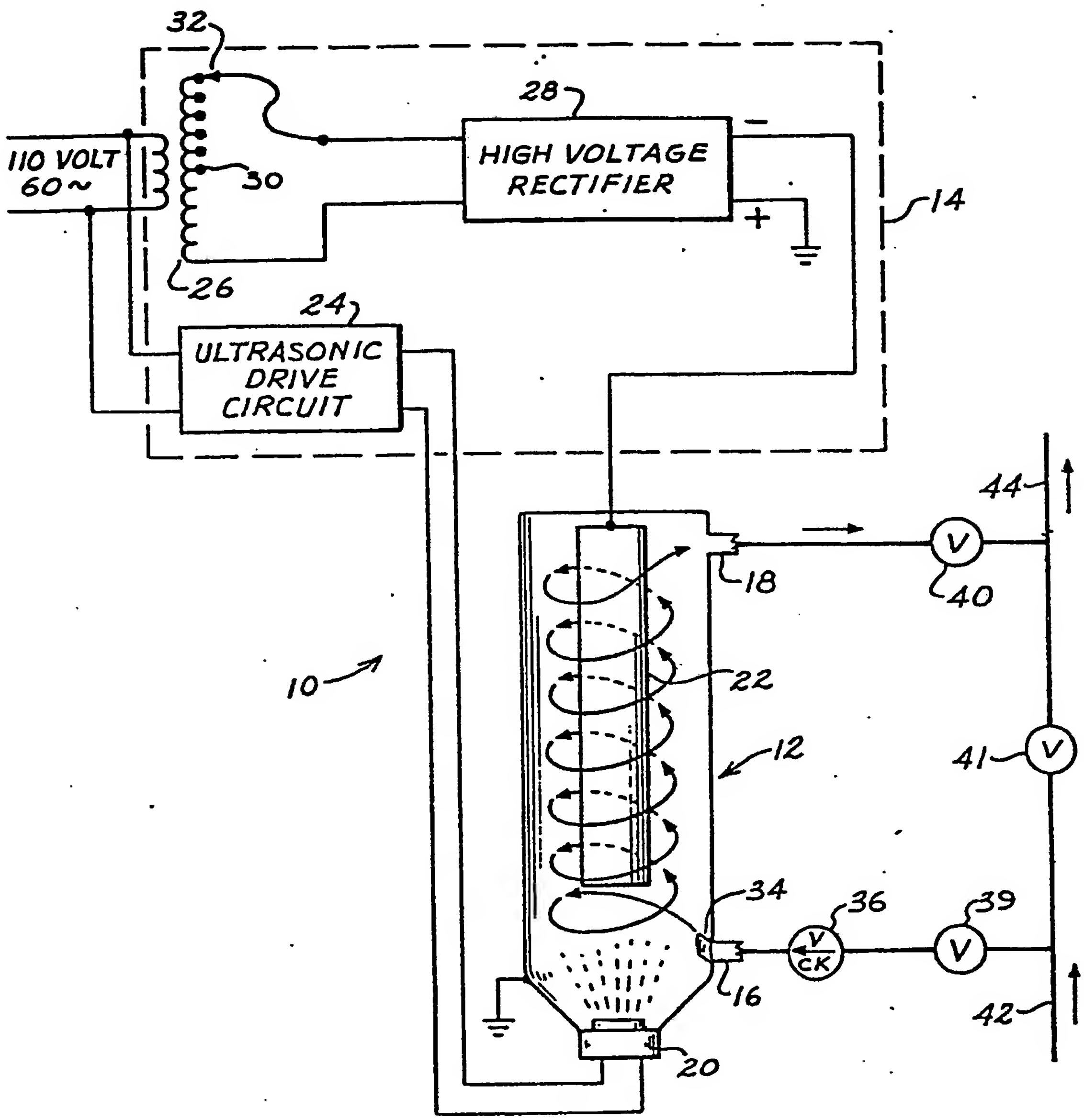
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Fig. 1

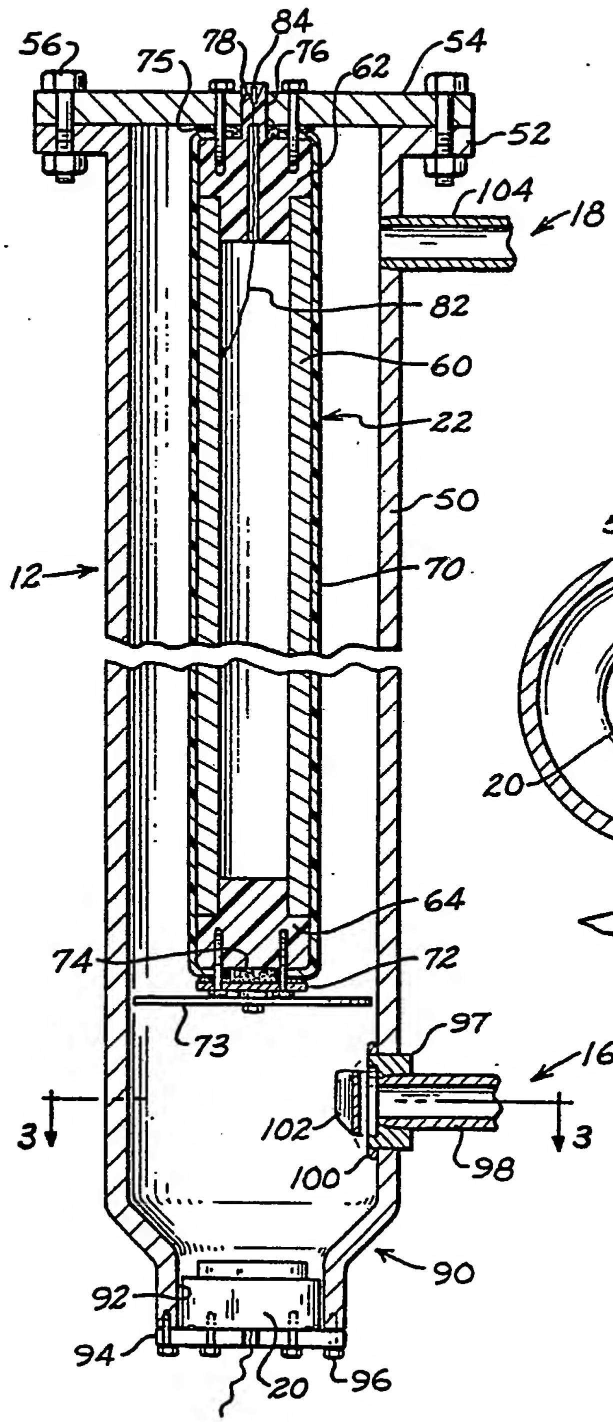
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Fig. 2

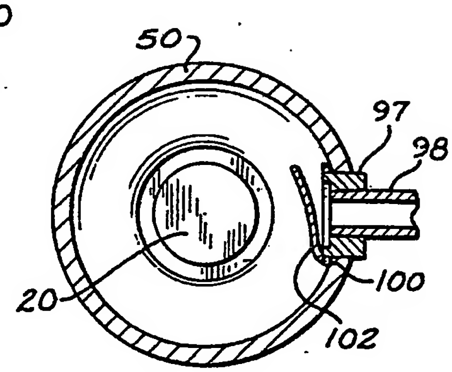
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Fig. 3

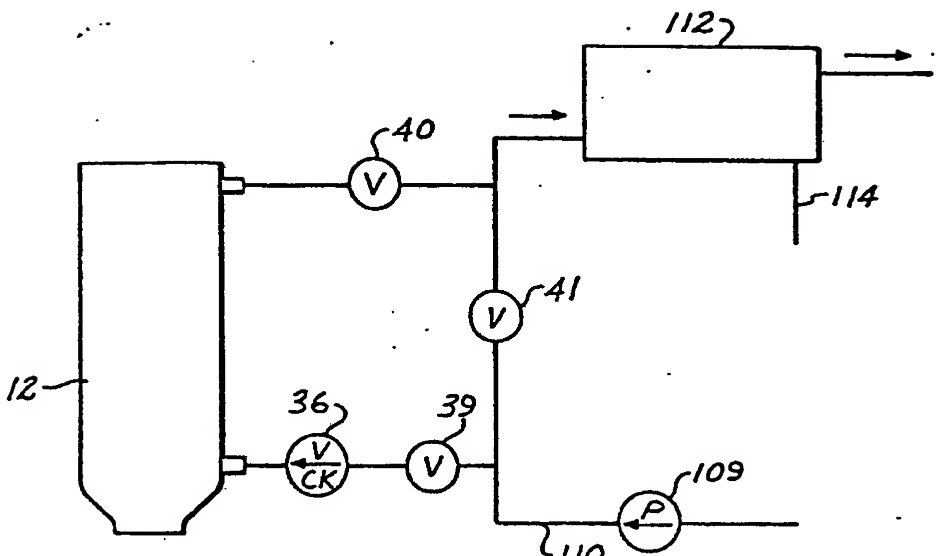
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Fig. 4

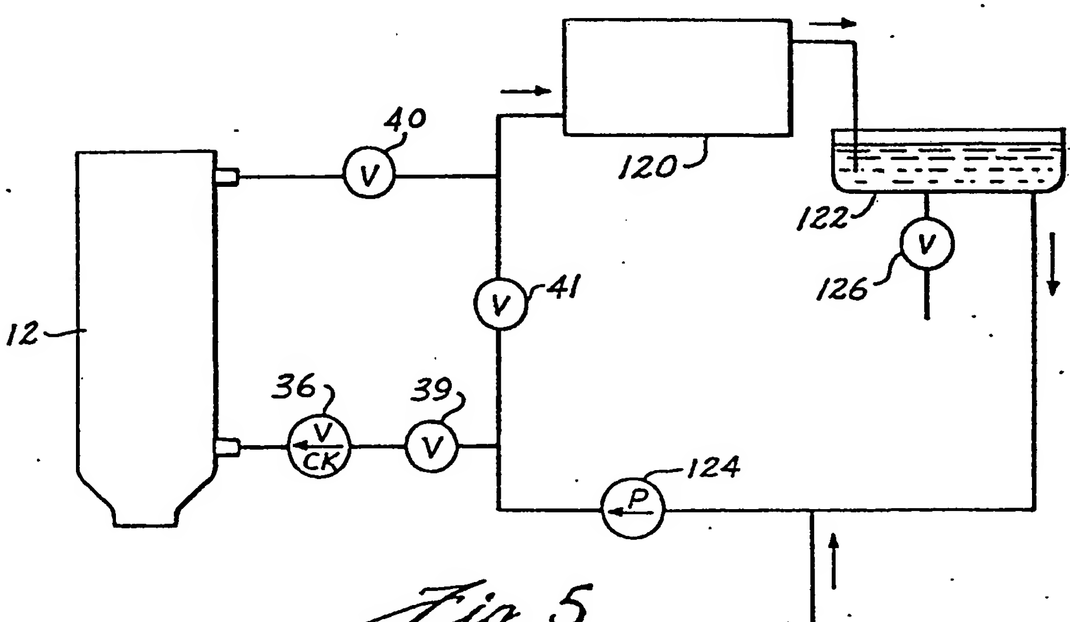
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Fig. 5

INTERNATIONAL SEARCH REPORT WO 80/00226

International Application No PCT/US 79/00522

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl. B03C 5/02
Us Cl. 204/307

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols	
US	204/149 204/307	210/243 Digest 22 422/128

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X	GB, A, 1,189,888, Published 29 April 1970, Chemolimpex Magyar Vegyiaru Kulkereskedelmi Vallalat, of Déak Ferenc utca 7-9	1-10
X	BE, A, 505,334 Published 15 September 1951, Societe De Physique Appliquee	1-10
L	N, Welder et al, Practical Performance of Water Conditioning Gadgets, Industrial Engineering Chemistry, Vol. 46, No. 5 (1954) pages 954-960	1-10
L	N, Anon, Federal Trade Commission Decusion on Evis Water Conditioner Claims, Journal of American Water Works Association, Vol. 51 (1959) pages 708-709	1-10

* Special categories of cited documents: [15]

"A" document defining the general state of the art

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"T" later document published on or after the international filing date or priority date and not in conflict with the application, but cited to understand the principle or theory underlying the invention

"X" document of particular relevance

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
22 OCTOBER 1979	06 NOV 1979
International Searching Authority [1]	Signature of Authorized Officer [10]
ISA/US	Howard S. Williams HOWARD S. WILLIAMS

Form PCT/ISA/210 (second sheet) (October 1977)

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

L	N, Gordard, Watch Out for Wonderous Water Treatment Witchcraft, Materials Performance (NACE) 1974, page 9	1-10

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [10]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers ______, because they relate to subject matter [12] not required to be searched by this Authority, namely:

2. ☐ Claim numbers ______, because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [13], specifically:

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [11]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.
2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:
3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.
☐ No protest accompanied the payment of additional search fees.